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Energy Optimization for Smart Housing Systems

Medha Misra[1], Pawan Singh[2], Hasan Haes Alhelou[3]

[1,2]Department of Computer Science and Engineering, Amity School of Engineering and Technology, Amity University Uttar Pradesh, Lucknow, India
[3]Tisheen University, Lattakia, Syria
[1]themedhamisra@gmail.com

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Abstract

Smart home is an emerging technology which is growing continuously now. It integrates many of the new technologies with the help of home networking for improving human's quality and standard of living, so there are many projects which are researching in diverse technologies in order to apply them to the smart home system. As the technology evolves it comforts mankind with some additional ease and advancement. At the time the evolution calls upon all the daily routine devices to operate over internet and this project is based on the idea to make these devices accessible to the owner anytime anywhere. Particularly for now we intend to connect electrical appliances in any house to a kind of a local area network so that it can be operated by the respective authorities so as to minimize the electricity wastage. Further these devices along with sensors can be made to operate on their own, intelligently and accurately. The excellency of the project can be utilized in hostels and classrooms as well where most of the times we find electrical appliances operational even when not necessary. The idea is to turn a house into a smart house. The project utilizes the current technology such as wifi and low-cost electronic modules to meet the requirements of IOT and gives it a web as well as an app interface for an ease of access. The technologies which we are using include - Wifi module, Relay module, Raspberry pi, Sensors for automatic support and feedback to user. The project can be extended to cloud also for data storage and providing access to authorized user.

Keywords

Smart home, Wifi module, Raspberry pi

1. Introduction

"ENERGY OPTIMIZATION FOR SMART HOUSING SYSTEMS" is a software and IoT solution to save electricity in our homes. This project aims at providing an easy access to use interface to control the lights and fans in our homes. This project has four

major components namely, The Server, Android Mobile Application, Web based Application and Hardware. There are two modes in which this IoT model operates:

Automatic Mode: The IoT works purely based on the percept sequence it receives from its sensors.

Manual Control Mode: The operator has to control the lights and fans manually from the app's control panel.

This project uses ESP8266 and raspberry pi to build a complete sensor network. The raspberry pi runs an API server which connects it to our android mobile application. The android mobile application presents user with a user-friendly UI and provides full control over their appliances. The user can view the current state of the room through the web-based application also but cannot control or manipulate it.

In the mobile application we have two major sections namely:

Control Centre- this section of the app provides the manual control to the operator to turn on / off the lights and fans.

Monitor- this section of the app will display the data collected from the sensors in readable format to our operator / user.

Numerous research papers and books are explored to get a better insight on the topic. One study (Home Automation using Android Application & Bluetooth) has shown that how smartphones can be used to connect to different appliances and control them. It uses bluetooth to establish the connection. It utilizes bluetooth module to create the sensor network. While the above studies provide valuable information regarding Home Automation using Android Application & Bluetooth, another research paper (Internet Programmable IoT: On the role of APIs in IoT) gives a better understanding of the role that REST API plays in IoT. Another research paper (Active RFID and ESP8266 based Child Monitoring System) gives a better understanding of how to work with ESP8266. It tackles the problem of child abduction from hospitals. The idea proposed in this research work will help reduce the risk of the same. It has got three components namely Android Module, Arduino Radar Module and ESP8266. When exploring cloud for IoT, a very interesting research work was studied (Stack4Things: a sensing-and-actuation-as-a-service framework for IoT and cloud integration). In this research work, the study was conducted on different services model of cloud computing such as Software as a Service (IaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). While the above studies provide valuable information regarding the subject but to better understand this field a book (Practical Internet of Things Security by Brian Russell, Drew Van Duren) was also referred. It takes its readers on a journey that begins with understanding the concept of IoT and thus how it can be applied in various industries. It also goes on to describe the security challenges which are associated with the IoT, and then it also provides a set of guidelines which can help to architect and deploy a secure IoT for any of our enterprise. The mentioned book showcases, how the IoT is implemented in early-adopting industries and also describes how lessons can be learned and shared across diverse industries in order to support a secure IoT.

The structure of the paper is as follows: In the next section the motivation and scope is presented. In section 3 the problem statement is declared. Section 4 shows the methodology used and section 5 gives the concluding remarks.

2. Motivation

The motivation for doing this project was the curiosity to create something new to save energy; to implement a real time product [1]. The crucial factor which motivated the authors for working in this field was the considerable amount of electricity wastage by our beautiful homes (even when not needed). And as a student of Computer Science and Information Technology, it is quite interesting to be able to equip our homes with automation technologies, and the attractive as well as interactive platform, Internet of Things. These are few of the most important reasons why this topic was selected to work on. Presently, the homes are technically sound that they need a lot of electrical supply but that does not account for switching appliances off when not needed, and this project helps us in switching them off automatically by sensing the environment

and can be switched on automatically too. Besides this, the authorized user can forcibly switch on manual mode and force the appliances to be on and off as per their wish. The beauty of our homes equipped with smartness can be an example of advancement in the field of Information Technology. So this idea was quite innovative and thus I thought of changing this idea into reality.

2.1. Scope

As of now, all electrical appliances are considered; its scope can be increased to non-electrified things too by using actuators, which can enable a range of functionalities, such as - opening and closing of doors or switching gas off in kitchen and a really good amount of other household things. One of the constraints in case of tracing temperature was that I wasn't able to trace it more frequently than every 2 seconds which can lag in extreme situations especially when we will be needing real time data. Hence the present scope of the project is based on digital data (on or off switches) [2]. I am not being able to feed analog (some amount of electricity) data to appliances. Still, I am struggling to detect the presence of a person in the environment around the set up if they stop moving for some time, as then the PIR sensors won't be able to detect their presence. But still we can use ultrasonic sensors in cooperation with PIR sensors to improve the accuracy further, but even then, the hundred percent accuracy of detection cannot be assured.

2.2. Problem Definition and Objective

According to a Times of India (TOI) report around 27% of energy in India gets wasted in various forms. And that is of great concern for a country like India where 250 million live without electricity. This project intends to connect the electrical appliances in our homes to a network so that they can be operated on the fly over wifi networks [3]. The objective is to minimize electricity wastage in our homes. The objective also aims at providing robust modules so that they work durably. And to also make them as cost effective as possible. In future it can be extended to clouds for further implementation and also for wide range of authorization and data handling. This project plans at estimating the electricity consumed by the appliances by analyzing the data which will be stored on the clouds in the future [4].

3. Problem Statement

3.1. Security Challenges

Smart homes usually come with some of the various security concerns. For instance, if some hackers accessed our network system, then they will have the power to control all our installed smart devices especially the appliances which are responsible for our security [5].

3.2. New Environment Adaption Challenges

Owning a smart home means, you have to learn as to how to use your home, as it now requires you to adapt to all the innovations around you such as, the security systems and all the sensors, that function all the time to detect your movement. Accordingly, it will require reading manuals and in order to learn about how-to of your home.

3.3. High Intelligence Cost

Although smart homes generally have many appliances and gadgets that ultimately make our lives convenient. These smart properties of a smart home come with a higher price tag. The effective cost of an intelligent home is usually high because

some of its technology is relatively very new. However, in most cases, the standard techniques of home automation have few enhancements. The cost of other aspects when considered can be very expensive as well.

4. Methodology

Wifi module ESP8266: This module has some significant features which makes it useful in this context. Besides being cost effective it has tremendous amount of GPIOs, its inbuilt web-server facility enables to feed data in it and also enables the module to respond to web requests. The specific model considered is ESP8266 ESP-12E NODE MCU. Its wireless communication facilities are equipped with 802.11n.

PIR Sensor: Passive Infrared sensor is also deployed which detects presence of warm bodies in its range and the angle. Its working is quite complicated, but the requirement is to detect the presence of any person in the required range.

Temperature Sensor: The temperature sensor considered is DHT22 which senses temperature as well as humidity very efficiently. The only downside is we can query the temperature once every two seconds only and not more frequently than this. It is a matter of less concerned.

Relay: Four channel relay is used in my project which can switch 4 devices per module.

Raspberry Pi: Raspberry Pi 3 is used with so many advancements such as inbuilt wifi and bluetooth and thus it also solves many problems as a master configuration for our ESP8266 modules. It receives the data that sensors feed to wifi module over wifi network and then processes it further as per the requirement.

Ultrasonic sensor: Ultrasonic sensor is used to detect number of persons entering in the room.

Android Based Application: Android application makes a request to our master raspberry pi to process data the way application wants and sends it back to the application in response to the request. After this is fulfilled, application uses the supplied data for the best possible user experience. The user interface of android based application is shown in figure 1 and2.

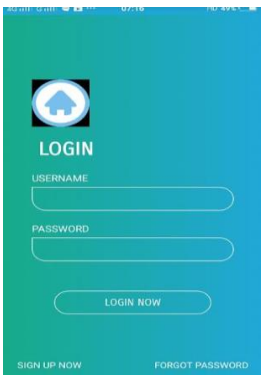

Figure 1. Android Application login Interface

Figure 2. Android Application Interface

Web Based Application: Web application makes a request to our master raspberry pi to send the required data. After the request is fulfilled, application uses the supplied data for the best possible user experience. As shown in figure 3.

Integrating Parts: So how these things communicate with each other to achieve the goal of automation or manual control through applications is a bit complicated. The communication of different parts of the project is reflected in the figure 4.

Figure 3. Web Application Interface

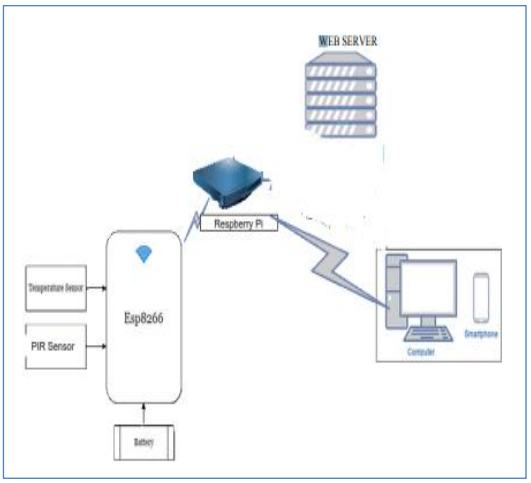

Figure 4. Integration of the various parts of our project

Let's start from the sensor, sensor senses the environment around and passes information to the wifi module(slave) which then sends the data to raspberry pi(master) the raspberry pi in turn commands the switches to be on or off as per the automatic or manual mode. Also, when user would want to query about their home appliances Raspberry pi feeds the sensed data to application and thus enhances the user experience. The communication structure is shown in figure 5.

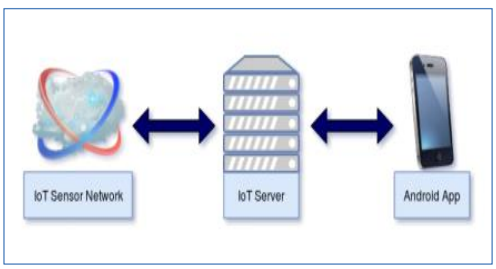

Figure 5. User interaction with our project

4.1. Requirements

Software Requirements - Ubuntu 16.04 LTS, android studio, flask and arduino tool kit.

Hardware Requirements- ESP8266, raspberry Pi 3, relay module, temperature sensor, PIR sensor, LDR, ultrasonic sensor, adaptor, and webcam.

5. Conclusion

The focus of the study was to remotely control the appliances like fan, light and AC etc. with the help of the internet. This project now remotely controls all these appliances and then checks whether it is in switched off or on state. All the devices have their own relay from which we can know whether they are in ON or OFF state. So, we have basically implemented our hardware and software both for the above-mentioned work. After that, we have tested our implementation and debugged the same. Now by mixing all these things hardware and software it turned out to be a great combination of electronic devices and internet which saves our time, electricity, and money which are our basic requirement.

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